

## The Fine-Scale Structure of the Interplanetary Magnetic Field

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The interplanetary magnetic field is the magnetic field carried away from the Sun by the solar wind. The Sun rotates as the solar wind carries magnetic flux away from the Sun, so that the footpoint of each magnetic field line is twisted around in the direction of solar rotation. The resulting spiral magnetic field, an Archimedian spiral, was predicted long ago by Parker.<sup>1</sup> Superimposed on the average interplanetary magnetic field spiral is a fluctuating component, which has been examined using Ulysses data.

To study the fluctuating component requires a timing mark—something in the interplanetary magnetic field that can be identified and followed from one location to another. The only such feature is the surface across which the direction of the field changes. This is a continuous surface dividing the magnetic north of the Sun's field from the magnetic south. Over the 11-year sunspot cycle, the Sun's magnetic dipole is sometimes tilted by up to 90 degrees away from the rotation axis, and the surface dividing these two magnetic hemispheres—known as the “heliospheric current sheet” because it contains a large-scale electrical current—is similarly tilted. This sheet can be used as a timing mark both to study and to depict the magnetic field's fluctuating component. The average heliospheric

current-sheet location just follows the Archimedian spiral of the average interplanetary magnetic field.

Solar wind plasma data, collected by an instrument on Ulysses,<sup>2</sup> were analyzed to determine the character of the fluctuating velocity vector in the vicinity of the heliospheric current sheet. A simple model was then developed to compute how the fluctuating velocity would deform the sheet as the magnetic field is carried away from the Sun by the solar wind.

Results have shown how the interplanetary magnetic field is distorted by the solar wind: the fluctuating magnetic field predicted using a simple model was like that which was observed. This straightforward explanation has largely replaced more complex explanations involving fine structure in the solar corona and waves on the heliospheric current sheet. Figure 21 provides a calculation of the fluctuating sheet made using data from the Ulysses solar wind plasma instrument. The eddies in the solar

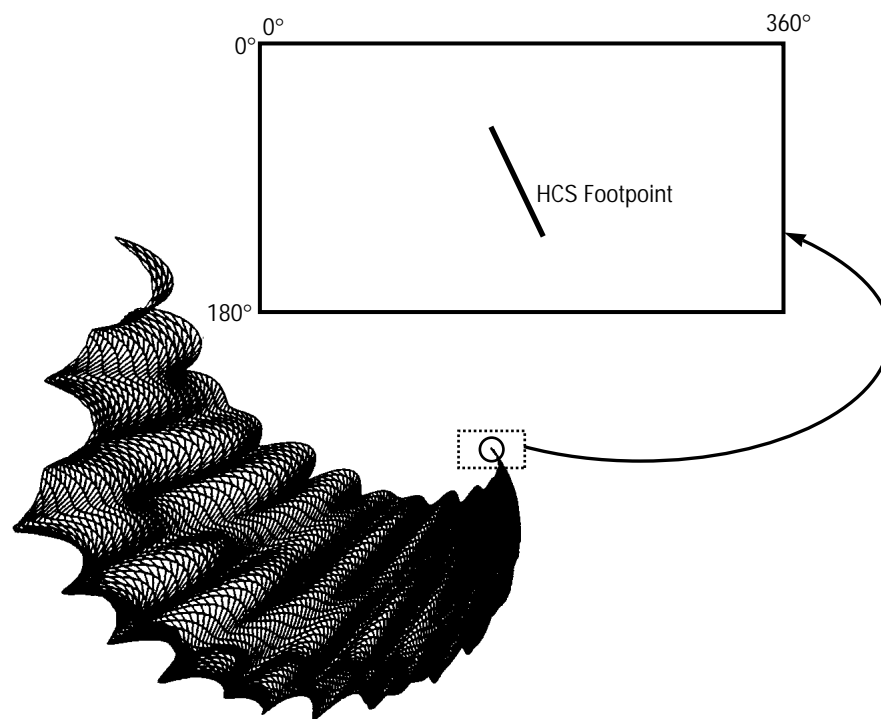


FIGURE 21.—A local section of the heliospheric current sheet centered on the equator, inclined at 70 degrees to the equator, extending over 10 degrees in longitude and 27.5 degrees in latitude. The section shown is between the Sun and 2.0 astronomical units. A projection of the footpoint of this section onto the Sun, in Carrington coordinates, is shown above. The topology of the sheet has been computed in this case for a fluctuating radial-velocity amplitude of  $\pm 25$  kilometers per second and transverse amplitude one-seventh as large.

wind move the sheet around so that its smoothly inclined section (shown near the Sun as a straight line) becomes the highly “ruffled” surface at 2.0 astronomical units (twice the distance from the Sun as the Earth’s orbit).

<sup>1</sup>Parker, E.N. 1963. *Interplanetary Dynamical Processes*. Wiley-Interscience: New York.

<sup>2</sup>Suess, S.T. 1995. Solar Wind Eddies and the Heliospheric Current Sheet. *Journal of Geophysics Resources*, 100, 12, 261–12, 273.

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